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BUTTER

ITS ANALYSIS & ADULTERATIONS

BY

ARTHUR ANGELL, F.R.M.S.

AND

OTTO HEHNER

BUTTER:

ITS ANALYSIS AND ADULTERATIONS.

SPECIALLY TREATING ON

THE DETECTION AND ESTIMATION OF FOREIGN FATS.

BY

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PREFACE.

THE Authors have been urged to undertake the production of this small treatise, by a conviction that no work has hitherto been placed into the hands of the "Food Analyst," which gives reliable methods to detect and estimate foreign fats when mixed with butter.

To take one article of food, and to describe a method of detecting adulteration in it alone, is indeed a work of no great magnitude; nevertheless, by paying special attention to their subject, and by giving a number of new facts in connection with it, the authors hope to have supplied a want.

The authors give two entirely new and original methods, described in Chapters IV. and V.

The first, a physical one, determines the fusing points; the second, a chemical one, for estimating foreign fats in butter.

The chemical research is mainly due to

Mr. Hehner, whilst the physical and microscopical part is more peculiarly the work of Mr. Angell.

To Dr. Hassall, in whose laboratory the whole of the experiments have been done, the authors are deeply indebted.

May this little work be favourably received by the Analysts and the trade: giving to the one accurate methods for detecting adulteration, and protecting the other from unjust prosecution under the "Adulteration Acts."

VENTNOR, *July* 4, 1874.

CHAPTER I.

THE COMPOSITION OF BUTTER.

BUTTER consists of the fatty portion of the milk of the cow, in which it is suspended in the form of minute oil-globules.

On allowing the milk to remain undisturbed for some hours, these globules rise to the surface, forming a layer of the so-called cream, which, besides the fat, contains a quantity of casein, and some serum. By violent agitation, the oil-globules of the cream break up, and, uniting, form a fatty mass, which invariably contains a small quantity of the casein and water of the milk. In this country, some salt is generally added during the process of preparation.

Butter obtained in this manner may vary much in colour and flavour, which qualities are governed by the season, food, kind, and health of the cows, but mostly depend upon the care and cleanliness observed during the manufacture. Thus, it is well known amongst makers that a person with warm moist hands is unable to produce a butter of fine flavour. From the same cause, butter begins to decompose in a very short time, on the spot, touched with a sweaty finger.

The better a butter has been prepared, the more even is it in texture, pellucid in appearance, and the longer will it keep.

The constituents of butter, therefore, are fat, water, casein or curd, and salt.

I. *The Fat of Butter.*—Like all the other fats, the fat of butter consists of a mixture of the glycerides of the so-called fatty acids,—palmitic, stearic, and oleic,—but, moreover, as characteristic features, it contains butyric, caproic, caprylic, and capric acids, in combination with glycerin. To obtain an insight into the constitution of butter-fat, it is necessary to pay some attention to the physical and chemical properties of its proximate constituents.

Palmitin is a white solid, fusing at 36° C., and crystallizing in laminæ. It is insoluble in water and cold alcohol, but soluble in hot alcohol and in ether. It occurs in nearly all fats, especially in those fusing at the lower temperatures. On decomposition it yields 95·28 per cent. of palmitic acid, $C_{16}H_{32}O_2$.

Stearin resembles palmitin in appearance, fuses at 63° C., but is less soluble in alcohol and ether. It occurs in most fats, in the largest proportion in those having a high fusing point, and yields 95·73 per cent. of stearic acid, $C_{18}H_{36}O_2$.

Olein is at ordinary temperature an oily liquid, solidifying at 5° C., and is soluble in ether in all proportions. It is the predominant constituent of the fat oils. The quantity of oleic acid obtained from it amounts to 95·70. Its formula is $C_{18}H_{34}O_2$.

Butyrin is the most important constituent of butter; although not occurring in it in as large quantities as the olein, it imparts to it its peculiar flavour and smell, and distinguishes it from all other fats. It is at ordinary temperatures an oily liquid, yielding on decomposition butyric acid, $C_4H_8O_2$.

Butyric Acid belongs to the series of fatty acids, although it resembles in appearance and physical properties, acetic more than the palmitic, stearic, or oleic. Its specific gravity is 0·97. Boiling at 157° C. It smells strongly acid, like acetic acid and rancid butter combined; it is volatile and soluble in water, alcohol, and ether in all proportions. Butyric acid has also been found in large quantities in the locust bean (*Siliqua dulcis*), in the fruits of the soap-tree and of *Gingko biloba*, in sour gherkins, and in the sauer-kraut of the Germans. It occurs further in small quantities in some mineral springs, and is formed by the fermentation of sugar, starch, and lactic acid, in which way it is artificially prepared. It is found in no other fat but butter.

Caproic Acid, $C_6H_{12}O_2$, is a liquid possessing a sudorific smell, boiling at 202° C.; specific gravity 0·922. It is volatile and soluble in water and alcohol. It is not only found in butter, but also in cocoa-nut oil, which is said to contain, moreover, caprylic and capric acids. It occurs in human sweat, in cheese, in the root of *Arnica montana*, in *Satyrium hircinium*, and in the fruit of *Gingko biloba*.

Caprylic Acid, $C_8H_{16}O_2$, closely resembles in all respects caproic acid; but its boiling point is higher, 235° C.

Capric Acid.—$C_{10}H_{20}O_2$, is at ordinary temperatures a white crystalline body, fusing at 29·5° C., not volatile to any considerable degree, slightly soluble in water, but easily in alcohol and ether. It smells like the sweat of the goat; whence its name. It occurs in butter, cocoa-nut oil, cod-liver oil, and the fusel oils obtained by fermentation.

As far as we are aware, only a single analysis of the fat of butter has ever been published, which one, moreover, is very unsatisfactory and deficient in accuracy. It is by Bromeis, and given by Fremy and Pelouze in the "Traité de Chimie":—

Margarin	68
Butyrolein	30
Butyrin, Caprin, and Caproin	2
	100

The margaric acid of Bromeis has been proved by later investigators to be really stearic acid, associated with volatile acids this explains why Bromeis found such a small quantity of volatile acid. At the same time, it has never been proved to satisfaction, that there is any difference between the oleic acid of butter and that of other fats. "It appears from the experiments of Gottlieb, that it is really identical with oleic acid, and exhibits the characters observed by

Bromeis, only after it has been considerably altered by exposure to the air." (Watts's Dictionary.) As will be shown in a further chapter, the quantity of volatile acids is much more considerable than the analysis of Bromeis shows. There are, until now, no methods for separating stearic from palmitic, or even perfectly from oleic acid, and all analyses dealing with these bodies as separate constituents, can only be approximate.

II. *Water.*—The most variable constituent of butter is water; according to the care which has been employed in the process of manufacture, smaller or larger quantities are incorporated in the butter; to remove it entirely by mechanical means is practically impossible. As an absolutely valueless constituent, it should be squeezed out as completely as possible during the preparation of the butter. The buyer and consumer of butter intends only to purchase the fat, and should, therefore, never get a large proportion of water, paying the same price for it as for butter.

Butter supplies to most people the largest amount of fat they take. Dr. Parkes estimates "that most persons take from 1½ oz. to 2 oz. daily;" so that it is a matter of great importance to every individual to get pure butter, and not, as sometimes happens, 15 or 20 per cent. of water. Good and carefully-prepared butter should not contain more than 10 per cent., and it can easily be made with much less. Any considerable excess should be treated as an adulteration, or, at least, as evidence of culpable carelessness on the part of the manufacturer. Hassall, Parkes, and Calvert fix the normal amount of water at from 5 to 10 per cent.; Wanklyn, to 12 per cent.; Watts gives 1 per cent., which is certainly a misprint. Our experience has led us to agree with the former observers. Very frequently, however, a much larger percentage of water is met with; thus Hassall found that the amount of water ranged, in salt butter, from 8·4 to 28·6 per cent., and in fresh butter, from 4·18 to 15·43 per cent. Wanklyn found in fifty samples of the butter as supplied to the London workhouses in the year 1871, water ranging from 8·6 to 23·7 per cent. We have met, in one case, with the extraordinary amount of 42·3 per cent. Three methods may be adopted in order to produce an excessively aqueous butter,—either the milk is purposely left in undue proportion during the manufacture, or it is afterwards added by stirring the fused butter with water; but if this mixture be not very rapidly cooled, crystals will be formed; or, lastly, the butter and the water may be triturated together in the cold, which seems to us to be unpractical, inasmuch as it gives rise to a lightness in colour and texture, caused by enclosed air-bubbles, which does away with all resemblance to genuine butter.

An unusually low percentage of water is likewise a suspicious characteristic. If a butter containing a normal amount of water be mixed with foreign fats containing no water, a diminution of moisture will be the natural result. Thus we met with a sample, Analysis No. 13, Chap. II., containing only 3·83 per cent.

Casein, or Curd, is the nitrogenous matter contained in the milk, which is invariably skimmed off with the cream, and thence finds its way into the butter. Taking the average of our analyses, we find that butter contains about 2·5 per cent., ranging from 1·6 to 5·1 per cent. Hassall and Parkes give from 3 to 5 per cent. Casein, however, may be mixed with butter in much larger proportions, so as to give rise to the so-called cheesiness. The less casein a butter contains the better, since this substance, like all other albuminous matter, is likely to induce decomposition, by acting as a ferment. The keeping properties of a butter, therefore, are in ratio with the amount of casein present. An excess of casein renders necessary an excess of salt to counteract the pernicious influence of the nitrogenous matter; consequently a careless manufacturer gets the benefit of the increase in weight by both substances.

Salt.—Our experience teaches us that butter contains on an average 2·5 per cent. of salt. Butter is spoken of as either fresh or salt butter: this distinction is convenient for commercial purposes, but would be a useless introduction in our case, as no distinct line can be drawn between the two; to each salt has been added, whether it be a so-called fresh or salt butter.

Hassall found the salt in one instance as high as 28·6 per cent.; Wanklyn's fifty analyses give a range of from 0·1 to 10·7 per cent. We think that the amount of salt in any butter should never exceed 8 per cent. An excess of salt is commonly accompanied by an excess of water, and frequently by an excess of curd; it would not be practical to use salt alone as an adulterant, since it is so easily detected by taste, and therefore reduces the commercial value to a greater extent than it increases its weight.

CHAPTER II.

ON THE DETERMINATION OF THE CONSTITUENTS OF BUTTER.

THE substances with which we have to deal in this chapter are water, casein, salt, and fat: the analysis of the latter will be specially treated with in another chapter.

For the estimation of water two processes may be employed. The first and older process is frequently recommended, but, as may be seen, it can give only approximate results. It consists in fusing the butter in a graduated tube about half an inch in diameter, and similar to those used for the estimation of cream in milk. The butter fat separates, in consequence of its low specific gravity, the water, salt, and curd sink to the bottom, the amount of water is read off on the graduated scale. It is evident that this method is better adapted for the estimation of the fat than of the water.

The second is the chemical, and the only reliable method, consisting in drying a weighed quantity of butter in a porcelain or platinum vessel at the temperature of boiling water, till all moisture is driven off. The dish should not be too small, as it is necessary frequently to agitate the fused butter, so as to facilitate evaporation. If the dish be too small and deep, the water simply sinks to the bottom, and therefore does not evaporate.

A quantity of about 3 to 4 grammes is sufficient. The loss of weight multiplied by 100, and divided by the quantity of butter taken, gives the percentage of water. It is true that not only water is volatilized in this process, but also free butyric acid, if any be present, as is the case in rancid butters; but this fault is certainly much too small to be considered as an objection against this method.

The butter thus freed from water, must again be fused and dissolved in about 10 cc. of ether. The ethereal solution of fat is now filtered through a weighed filter, to separate it from the curd and salt, which are to be washed with ether, until a drop of the filtrate evaporated upon a glass slide no longer leaves a greasy spot. The perfect removal of the fat is not very easy, and a comparatively large quantity of ether has to be used. The filter is dried in the water-bath, and weighed between two watch-glasses, so as to prevent any absorption of moisture from the atmosphere.

In order to save trouble, filters, instead of being weighed, are often counterbalanced by placing another filter of apparently the same size and weight upon the opposite side of the scales; this method is unreliable, since filters stamped out from the finest Swedish paper differ as much as 30 milligrammes.

The residue, consisting of solids not fat, may now be burned to a white ash, which consists, in genuine butters, practically of salt only. The difference between the weight of the ash and that of the dry solids not fat, gives the amount of casein. If the butter be suspected to be adulterated with foreign mineral matter, an estimation of the salt, by the usual nitrate of silver method, must be made. The fat may be estimated either directly or by difference. The ethereal solution obtained in the estimation of casein and salt may be evaporated in a small weighed glass flask, capacity about 80 cc.; the ether may easily be saved by connecting the flask to a condenser: we can recommend a simple and effectual one, easily made, by bending a glass tube into a V shape, each arm being a foot long. The bent tube is immersed into cold water, and the ethereal solution treated to boiling by means of a water-bath. When nearly dry, the flask with butter fat is placed into the steam-bath, and dried till a constant weight is obtained, which process requires several hours. The direct estimation, and the estimation by difference, should agree within a few tenths of a per cent.

According to the plan of analysis described in this chapter, many determinations were made by us, some of which are appended, and may be safely taken as a fair illustration of the butters of commerce.

No. I. *Farm Butter from Chale, Isle of Wight.*

Water	9·709
Curd	3·462
Salt	2·089
Fat	84·740
	100·000

No. II. *Farm Butter from Niton.*

Water	10·063
Curd	2·799
Salt	0·672
Fat	86·466
	100·000

No. III. *Farm Butter from St. Lawrence.*

Water	12·984
Curd	2·721
Salt	0·424
Fat	83·871
	100·000

No. IV. *Sussex Butter.*

Water	11·168
Curd	3·143
Salt	2·006
Fat	83·683
	100·000

No. V. *Jersey Butter.*

Water	6·463
Curd	2·459
Salt	1·598
Fat	89·480
	100·000

No. VI. *Jersey Butter.*

Water	10·445
Curd	2·536
Salt	8·528
Fat.	78·491
	100·000

No. VII. *Normandy Butter.*

Water	9·305
Curd	5·137
Salt	2·915
Fat	82·643
	100·000

No. VIII. *Butter from Ventnor.*

Water	9·193
Curd	2·917
Salt	3·210
Fat	84·680
	100·000

No. IX. *Butter from Ventnor.*

Water	7·683
Curd	1·908
Salt	1·960
Fat	88·449
	100·000

No. X. *Butter fron Guildford.*

Water	8·580
Curd	2·789
Salt	3·151
Fat	85·480
	100·000

No. XI. *Butter from Winchester.*

Water	6·370
Curd	1·611
Salt	1·822
Fat	90·197
	100·000

No. XII. *Butter from Winchester.*

Water	8·615
Curd	2·054
Salt	2·108
Fat	87·223
	100·000

No. XIII. *Butter from Ventnor.*

Water	3·831
Curd	3·289
Salt	6·600
Fat	86·280
	100·000

No. XIV. *Butter sent from London.*

Water	23·981
Curd	6·880
Salt	1·559
Fat	67·580
	100·000

No. XV. *Butter from London.*

Water	42·358
Curd	7·834
Salt	2·689
Fat	47·119
	100·000

The first twelve analyses are without doubt those of genuine butter. The average of the fat is 85·45 per cent. Butter No. XIII. was purchased by us in Ventnor, and found to contain over 50 per cent. of foreign fat,—hence its small amount of water.

Nos. XIV. and XV. were sent from London for analysis, and were found to be mixed with milk; thus giving very large percentages of water.

Not one of the twelve pure butters contained any trace of crystals; after fusion, however, they all showed masses of stellate crystals, which gave a black cross under polarized light.

When first we applied our time specially to the study and examination of butter, we were inclined to set much value on the presence or absence of a tallowy odour and taste; we very soon found, however, that all butters, pure or not pure, salt or fresh, after exposure to the air in a divided state turned tallowy in appearance, odour, and taste. As a fact, eight butters known to be genuine were spread out with the spatula upon sheets of paper, and exposed to the air in the laboratory; on the third day each sample showed signs, more or less, of tallowiness, and at the end of a week those parts most detached from the bulk were in all cases indistinguishable from tallow, by the use of any of our senses.

CHAPTER III.

ON THE MICROSCOPIC EXAMINATION OF BUTTER.

MUCH has been said and written about the use of the microscope in connection with the detection of adulteration in food. By some chemists, pure and simple, this instrument has until very recently been viewed with distrust and jealousy; on the other hand, microscopists are apt to rush into a dangerous extreme, when their opinions are based solely upon a glance through the magic tubes. Undoubtedly, now a laboratory is no more complete without its microscope than without its balance.

Thus Dr. Campbell Brown has, we think, said too much in favour of the microscope in his paper on the subject, when he declared, in the following words,—"A microscopic examination with polarized light is the most reliable means of distinguishing pure butter from that which contains an admixture of less easily digestible and palatable fats."

Some decisions have recently been given in the police-courts, in consequence of reports or certificates, based mainly on the microscopical examinations of the samples, the analysts declaring that crystals were present.

Dr. Bartlett, in a letter to the *Times*, states:—"I find that the butter contains crystals of solid fat, palmitin, and stearin, which are plainly distinguishable from pure butter. Polarized light shows these crystals in a free state, which does not occur in butter free from admixture." He declared the sample to contain 20 per cent. of foreign fat, but he did not state how he arrived at this result. We do not venture to say that any of these decisions were incorrect, but certainly the data were unsafe.

It is eminently important that the value of the microscopical examination should be well understood, and restricted to its proper limits. A few careful experiments will enable any observer to prove the following facts for himself.

In no case does any fat in the raw state show traces of crystals; on the contrary, when a fat is fused, the membrane is broken up, and all the constituents are melted into an oily liquid, from which the stearin and palmitin partly crystallize out on cooling slowly. Beef, mutton, and pork fat in the raw state show large cells of adipose tissue, the contents of which depolarize light in an irregular manner, but are not in the least degree crystalline.

If a fused fat be cooled rapidly, no crystals are formed, as the following experiment will show:—One part of ox fat and two parts of butter, melted, and poured into cold water, exhibited no traces of crystals, but contained much water, which might have been expelled by pressure. The mixture kept its colour, and smelt fresh.

The assistance which the microscope, or rather micro-polariscope, renders, is therefore limited, and does not warrant anything more than apprehension. Crystals in butter are suspicious characters, but must not in any degree be considered as evidence of adulteration; but prove only that some part of it has been fused, which might happen on a hot summer day. On the other hand, the absence of crystals must not be taken as a proof that no foreign fats are present.

If some of a fat containing crystals be placed upon a slide, and a drop of castor or olive oil be applied, and pressed out with a thin glass cover, the depolarization of light is much enhanced. A revolving black cross, not unlike that of starch grains, is seen in great perfection. These crosses are most clearly defined in the crystals obtained from butter, and thus mounted, form a brilliant polariscope object for a one-third objective.

To mix foreign fats with butter without fusion seems to us impossible; the mass resulting from a simple trituration in the cold contains so many minute air-bubbles, that it is quite light and porous, and loses all resemblance to butter.

CHAPTER IV.

THE FUSING POINT.

HITHERTO much notice has been taken of the fusing point of butter as compared with that of other fats, and there is sufficient difference to warrant all the trouble which has been taken. It will be seen by reference to the works of the various writers on this subject, that the estimate is rendered valueless in consequence of the want of constancy in the results obtained. The very gradual and almost imperceptible manner in which fats, particularly butter, begin to soften, melt, and liquefy on the application of heat, renders accuracy impossible. To illustrate this statement, we will first consider the methods by which various writers have endeavoured to fix the fusing point of butter and other fats. The first method adopted was to fuse the fat in a beaker, at as low a temperature as possible, to stir with a thermometer, and to read off as soon as it was considered to be fused. A trial of this method quickly brings the operator to the conclusion that it is unpractical; for the reason that no two experiments can be made exactly alike, and that no two observers watching the same experiment can agree when to say the butter is really fused. The softening begins at a low temperature, and goes on very gradually till the whole is liquid. No change takes place which is sufficiently striking to fix the precise moment to read the thermometer.

A method adopted by Drs. Parker and Campbell Brown brings the fusing point rather more under control, and is, therefore, more valuable. The first observer makes use of these words:—"The best way of taking the temperature is to put a small quantity of butter into a test-tube, immerse it well in water, and heat the water gradually, observing its temperature by a thermometer." Dr. Campbell Brown describes an improvement upon this method, *Chemical News*, vol. xxviii., No. 710:—"Weigh out an ounce of the sample of butter which is to be examined, place it in a test-tube ⅞-inch in diameter, and melt by placing the tube in hot water; place a thermometer, with a pear-shaped bulb, so that the bulb shall be in the middle of the fat, about one inch below the surface, and allow the whole to cool spontaneously. If the quantity of water in the butter be large, it will collect in the tube below the fat; the casein will also collect in the lower part of the tube. Watch the mass as it cools, and note when solidification commences and when it is complete. The following are the average solidification points.

"With pure butter the thermometer is obscured between 23·3° and 20° C., and the mass is solid at 15·5° C. Beef dripping obscures the thermometer at 26·1° C., and is solid at 22·2° C.

"Mutton dripping obscures the thermometer at about 29·4° C., and is solid at 28·8° C.

"Lard obscures the thermometer at 28·8° C., and is solid at from 26·1° C. to 21·10° C., but it often remains as soft as butter at a much lower temperature.

"Mixtures solidify at intermediate temperatures."

Dr. Brown, in a subsequent number of the *Chemical News*, gives some figures obtained by the method just described: we give them in degrees centigrade on the opposite page.

Doubtless at the time Dr. Brown wrote his paper his method was the most exact; notwithstanding the discrepancies in his figures are many and puzzling. For instance, the "melting point," and that where "stem is indistinct," in some cases coincide, whilst in some it is 7 degrees below, and in others 10 degrees above that point. The most constant column is that headed "stem invisible;" but in this lard seems to behave in a most unaccountable manner, as in one instance it reads 35·5°, and in another, 24·4° C. Again, in the mixture of lard with butter, the method seems to break down entirely, inasmuch as the addition of 20 per cent. of lard brings the readings of the thermometer almost into coincidence with those of lard itself.

Dr. Atcherley, in his "Adulterations of Food," gives the following interesting figures:

"Beef suet begins to melt at 33°, and is

	When Heated.		On Cooling.			
	Softens.	Melts.	Obscures reading.	Stem indistinct.	Stem invisible.	Solid at
Butter from town-fed cows	20·5°	24·4°	28·3°	24·4°	22·8°	16·7°
Irish butter	23·9	31·7	22·7	21·7	20·5	16·7
Do. best	20·5	26·6	25·5	23·3	21·6	18·9
Do. low	24·4	31·7	27·7	25·0	23·3	20·5
Cornish butter	22·2	26·6	26·6	25·5	22·2	14·4
Canadian do.	23·3	32·2	21·6	20·5	20·0	18·8
Kiel do.	23·8	32·2	23·3	22·2	21·6	21·1
Suspected do.	21·8	35·5	41·1	28·8	24·4	22·7
Lard	28·8	35·5	—	—	35·5	29·4
Do.	26·1	30·5	26·6	26·1	24·4	20·0
Do.	30·5	35·5	26·6	26·1	25·5	23·3
Palm oil	27·2	33·3	—	31·1	26·6	20·5
Butter with 20 per cent. of lard	27·7	35·5	30·0	27·7	24·4	21·6
Butter with 20 per cent. of tallow	31·1	37·2	26·1	25·0	24·4	22·7
Butter with 50 per cent. of dripping	27·7	33·8	33·3	27·2	23·8	21·6

fluid at 55°; mutton suet begins to melt at about 38°, and is fluid at 66°; whilst butter shows signs of melting at 21°, and is quite melted at 49°;" thus, in butter, showing a difference of 28° between the "begins to melt," and the "is fluid."

We have dwelt for some length upon the methods hitherto used for estimating the fusing points of fats, in order to show the deficiency which renders them of little value if employed for the detection of foreign fats in butter. The range of temperature given is extremely large, but it is evident, that if chemists can agree to take always the same point as the fusing point, something like constancy may be obtained. Such a point is easily fixed. If a little weight be placed upon the top of the substance, the fusing point of which is to be estimated, it will sink as soon as the substance is so far liquefied as to present less resistance than the weight can overcome. The sinking point of the weight will nearly exactly coincide with the true fusing point, provided that the weight placed on the top is not too heavy in comparison to its bulk, as, for instance, a small piece of lead or brass would be. By making use of a glass bulb containing mercury, good results are obtained.

The bulb is made by blowing a small globe on the end of a piece of glass tubing of ¼-inch outside diameter, and drawing it off with a tapering neck, very near the bulb. By this means a pear-shaped float is obtained, the size and shape of which is given in fig. 1. Whilst the bulb is still warm, the open neck is dipped into mercury, and a small quantity allowed to run up into the bulb as the air contracts by cooling, in the same manner as thermometers are filled.

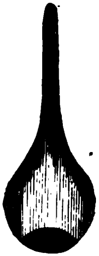

Fig. 1.

Sufficient mercury should be introduced to cause the bulb to weigh 3·4 grammes, which is the weight of the bulb used in our experiments. The bulb should displace as near as possible 1 cc. of water when immersed in a burette, its specific gravity being therefore 3·4°. Absolute accuracy is not necessary, since it was found that a slight difference,—say from 5 to 10 millegrammes in weight, or a little variation in shape, does not materially affect the results.

By using such a weight the sinking point of all butters comes within the limits of 3 degrees, and any number of observers witnessing an experiment would agree when to read the thermometer. Beef, mutton, pork, and other fats are also equally constant, providing they are taken from the same part of the animal.

Further, in mixtures of foreign fats with butter, the sinking point varies in ratio to the per-centage composition of the mixture, so much so, that in many instances the result arrived at by previous mathematical calculation practically coincides with the sinking point obtained.

Dripping or kitchen stuff, being often a mixture of different fats in unknown proportions, and having a sinking point very near that of butter itself, is an adulterant the presence of which the sinking point may give no indication; in this case recourse must be had to the estimation of fatty acids, which process will be spoken of further on. The reason why dripping has such a low sinking point is probably because it is composed of that part of the fat which is most easily fused in the process of cooking, in other words, it contains comparatively little stearin.

To take the sinking point of a butter, place 20 to 30 grammes of butter in a porcelain dish or glass beaker, and melt in the water-bath; when quite fluid, pour into a test-tube of ¾-inch interior diameter, and about 6 inches long, until filled to within about 2 inches of the top. Keep the tube warm until the whole of the water, salt, and casein has sunk, and left a perfectly clear fat; now solidify by immersing the tube in water of 15° temperature.

When quite cold, notice whether a dimple or hollow cone be formed upon the top; if so, it is a fact of sufficient importance to give rise to suspicion. Pure butter shows only a slight depression, whereas mixtures of a fat having a high fusing point, with butter, cool with a hollow cone: an admixture of 20 per cent. of mutton or beef fat with butter invariably presents this appearance. If a hollow be formed, the top part of the fat must be re-fused, so as to give a level surface upon which to place the bulb.

Immerse the tube containing the sample in cold water, contained in a beaker of the capacity of 1 litre: the top of the fat must be about 1½ inch below the surface of the water. A convenient method of fixing the tube in position, is to pass it through a hole drilled in a piece of wood, and placed across the top of the beaker; by this means two sinking points may be taken at the same time.

Having fixed the tube in an upright position, drop the bulb on to the surface of the fat. The arrangement is now complete, and heat may be applied by means of a Bunsen burner raised so as to just touch the sand-bath; the water should now be stirred at intervals, and the thermometer read off just as the whole of the globular part of the bulb has sunk beneath the fat. The arrangement of the apparatus is shown in fig. 2.

The following results have been obtained by this method; they are placed without

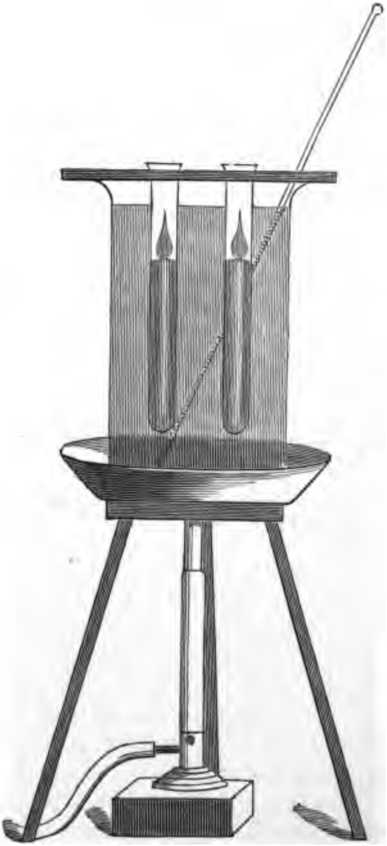

Fig. 2.

selection, in the order in which they were obtained.

Sinking Point with Genuine Butters.

NO.		CENTIGRADE.
1.	Butter from Town-fed cows .	35·3°
2.	Farm butter from Hertfordshire	36·1
3.	„ „ „ St. Lawrence	34·8
4.	„ „ „ Chale . . .	36·3
5.	„ „ „ Newport . .	35·3
6.	Butter from Ventnor	35·3
7.	„ „ „	35·5
8.	Farm butter from Niton. . .	34·8
9.	Salt butter from Ventnor . .	35·9
10.	„ „ „ „ . .	34·8
11.	Fresh butter from Ventnor .	35·1
12.	Farm butter from Chale . .	35·6
13.	„ „ „ „ . .	36·3
14.	Rancid butter	35·8
15.	Farm butter from Chale. . .	36·3
16.	„ „ „ Ventnor. .	35·5
17.	„ „ „ „ . .	34·3
18.	Sussex butter	35·5
19.	Normandy butter	35·7
20.	Butter from Ventnor	36·1
21.	„ „ „	35·3
22.	Jersey butter.	35·3
23.	Butter from Guildford . . .	35·7
24.	„ „ „	35·3

Average of the 24 samples . . 35·5 varying from 34·3 to 36·3.

Adulterated Butters.

1.	Butter from Ventnor,	1s. 2d. lb.	35·9°
2.	„ London,	„	42·7
3.	Kiel Butter	1s. per lb.	38·4

The sinking point of sample No. 1, as will be seen, is normal; we shall show, however, in the following chapter, that it was highly adulterated with a foreign fat having a low sinking point.

Sinking Point of Fatty Acids from Butter.

1.	41·8°
2.	42·1
3.	40·5
4.	41·1

Sinking Points of Fats other than Butter.

1.	Tallow from candle		53·3°
2.	Butterin (patented)		31·3
3.	Ox fat	from	48·3
4.	„	to	53·0*
5.	Mutton fat	from	50·1
6.	„	to	51·6†
7.	Lard	from	42·1
8.	„	to	45·3
9.	Dripping		42·7
10.	„ from beef		43·8
11.	„ „		44·5
12.	„ „ veal		47·7
13.	„ mixed		42·6
14.	Cocoa butter		34·9
15.	Palm oil		39·2
16.	Stearin		62·8

* Average, 50·6°. † Average, 50·9°.

Sinking Point of Mixtures.

No.	*p.c.*		*p.c.*		*Found.*	*Cal.*
1.	66·7	butter and	33·3	tallow	43·1	42·08°
2.	73·0	„ „	27·0	mutton fat	42·3	40·2
3.	10·0	„ „	90·0	„ „	48·8	49·6
4.	85·0	„ „	15·0	ox fat	38·1	38·1
5.	69·8	„ „	30·2	„ „	39·5	39·8

Problem: To calculate the sinking point of a mixture of known composition.

Multiply the per-centage of the first constituent by its sinking point.

Multiply the per-centage of the second constituent by its sinking point.

Divide the sum of the two products by the sum of the per-centage of the two constituents; or in formula:—

F being fat, and S sinking point,

$$\frac{F_1 \cdot S_1 + F_2 \cdot S_2}{F_1 + F_2}$$

Example 1.—Calculate the sinking point of a mixture of 75 mutton (sinking point, 50·1) and 25 palm-oil (sinking point, 39·2):—

$$\frac{75 \cdot 50{\cdot}1 + 25 \cdot 39{\cdot}2}{75 + 25} = 47{\cdot}37.$$

If butter be one constituent in the mixture, the formula will be somewhat modified, inasmuch as butter contains, besides fat, on an average, 15 per cent. of water, curd, and salt, which, being removed by fusion, must not be admitted into the calculation.

One part of butter, therefore, is equal to 0·85 part of fat; the per-centage of the butter present in the compound must consequently be multiplied by 0·85, to give per-cents of butter-fat, thus:—

$$\frac{0.85 \cdot B \cdot 35{\cdot}5 + F \cdot S}{0{\cdot}85 \cdot B + F}$$

Example 2.—Calculate the sinking point of a mixture of 66·7 of butter and 33·3 tallow (No. 1 of our list of mixtures):—

$$\frac{0{\cdot}85 \cdot 66{\cdot}7 \cdot 35{\cdot}5 + 33{\cdot}3 \cdot 53{\cdot}3}{0{\cdot}85 \cdot 66{\cdot}7 + 33{\cdot}3} = 42{\cdot}08.$$

The sinking point actually found, and that arrived at by calculation, will not often coincide exactly, 85 per cent. being taken as the mean, and not as an absolutely constant proportion of fat in butter.

CHAPTER V.

THE ANALYSIS OF BUTTER-FAT.

WE have shown in Chapter I that butter-fat has been analysed by Bromeis, who stated that it contained 2 per cent. of butterin and glycerides of volatile fatty acids. Calculated as butterin only, this number would be equal to 1·74 per cent. of butyric acid, $C_4H_8O_2$, since 302 of butterin contain 264 of butyric acid. We have shown at the same place that Bromeis's estimation is too low, since his "butyrolein" was proved to contain volatile acids.

Never since Bromeis does any attempt seem to have been made to estimate the exact amount of volatile acids in butter, notwithstanding that it must appear to every one a matter of the highest importance. It is well known that no other animal fat but butter contains volatile acids, and that therefore they are the characteristic constituents of butter. The appearance and flavour of butter are so very different from that of any other fat, that it appeared hardly credible to us that this difference could be due to only 2 per cent. of the glycerides of volatile acids. An exact estimation of these bodies promised valuable results.

It would be of considerable interest to know the proportions of stearin, olein, and palmitin contained in butter and other fats, but there are no methods of separating these bodies quantitatively. Moreover, if it were really possible to estimate these substances with accuracy, the results would be only of secondary importance, as mixtures of fats of high fusing point and of liquid oils could easily be made containing stearin, palmitin, and olein in the same proportion as they occur in butter. It has been denied by Dr. Tidy, in a paper read before the Society of Medical Officers of Health, that butter contains more than traces of palmitin, stearin, or olein. Dr. Tidy, however, leaves us totally in the dark what butter, in his opinion, consists of, and upon what ground his bold statement is based.

Let us now see what have been the methods most commonly employed for the detection of foreign fats in butter.

Many writers deny that there are any chemical means for distinguishing butter from other fats, or to detect admixtures of the latter with butter. Thus Dr. Edward Smith, F.R.S., says in his "Foods," page 135, "there are *no chemical means* of distinguishing pure meat fat, when added to butter, except by taste, which may indicate the absence of the flavour of butter, and the presence of another flavour not belonging to it; but the latter is usually avoided by adding a tasteless fat, as that of mutton, assisted by the more penetrating flavour of butter."

Professor Wanklyn agrees with Dr. Augustus Voelcker in his statement given before the Adulteration Committee of the House of Commons, in June 1874, that the composition of butter is so much like that of other fats, that the detection of adulteration by chemical means is impossible.

Other chemists, however, have endeavoured to find out chemical methods answering the purpose in view. It will be seen how far they have succeeded.

Dr. Campbell Brown, in the *Chemical News*, vol. 28, No. 710, describes a method, which is based upon the principle that butter contains less stearin than other fats, that, therefore, a solution of it in ether will, under certain conditions, give less deposit than a solution of these. Some samples of pure butter yield no deposit from three parts of ether at 18° C.; but fairly good butter will generally form a slight deposit, the amount of which varies in different samples. That the results of this method are anything but accurate appears from some experiments subsequently published by Dr. Brown. Thus, stearin from tallow gave only 32 per cent. of deposit from ether, the other 68 per cent. therefore being held in solution. From butter a deposit, varying from 0·39 per cent. to 4·36 per cent., was obtained, whilst lard gave the extraordinary range of from 0·82 per cent. to 14·33 per cent.

Another method has been described by Mr. A. G. Anderson, in a case which came before the Bow-street Police-court, in June 1874. We give it in his own words:—"I have analysed the contents of the packet, and found it contained water 1·07, and an admixture, which I am not able to determine precisely, of butcher's fat, which I detect by qualitative analysis. This so-called butter when melted has a congealing point of 19·4° C., while pure butter congeals at about 15°. Again, I have a saponification test, which, applied to pure butter, produces certain appearances which did not develop themselves in the case of this adulterated butter. This test is this—when we saponify pure butter, I uniformly find, that it darkens in colour, that it saponifies easily, and the olein, which separates afterwards, is dark in colour, and forms a jelly on cooling. In dealing with fatty matters, not butter, the reverse is the case, the fatty matter is improved in colour, and we get a clear light sherry-coloured fluid ley."

This saponification test is utterly fallacious. It is true that butter saponifies much easier than many other fats, and that the soap formed from it is somewhat darker in colour than that obtained from the latter; but it is quite impossible to tell by this method whether a butter is adulterated or not, mixtures all appearing very much like butter.

How the olein can separate after saponification, and form a jelly on cooling, we are at a loss to understand. If the concentration of the liquid be considerable, the soap separates from the strongly alkaline solution, and floats on the top, whether it be obtained from butter or any other fat. Happily enough, the case above alluded to was dismissed; but not upon the ground of the deficiency of the chemical analysis. The decisions in similar cases have been, however, heavy fines.

After perusing the many cases which have recently passed through the police-courts, we fear that we are justified in declaring that many condemnatory certificates have been based upon no method whatever, as is well illustrated by the following case, which was tried in April, 1874, at the Marylebone Police-court:—

The analyst stated that "he found in the sample of butter a considerable quantity of lard; in fact, it *was his impression* that the so-called butter was nothing but lard, mixed with palm-oil to colour it." Defendant was convicted, and fined £10, and £3. 3s. costs.

In another case, tried in the same Court, the sample was declared to contain "some fat."

Decisions, based upon mere *impressions*, are dangerous to the reputation of analysts, and unfair to the traders.

It was apparent to us that the only method, which could bring us nearer to the solution of the problem, to detect and to estimate foreign fats in butter, would be the determination, direct or indirect, of the butyric acid, the characteristic constituent of butter. We always look in chemistry for the characteristic constituents of the different bodies, why should we not do so in the case of butter? But it was stated that the total amount of glycerides of fatty acids in butter was only 2 per cent., so small a figure that it certainly misled many writers on the subject, and prevented them from carrying their investigations in that direction

The volatile acids amount to nearly 10 *per cent. of the butter-fat.*

Numerous estimations have convinced us of the truth of this highly important fact. In order to enable our readers to see the way through which we arrived at this result, we give a short sketch of the experiments which led us to this conclusion. Let it be borne in mind that we are speaking of butter-fat and not of butter, containing on an average of substances not fat, 85 parts of fat representing therefore 100 parts of butter. To obtain the fat in a state of purity, two ways may be pursued: the butter may either be washed with warm distilled water until no more salt can be detected in the solution by means of nitrate of silver, and then be dried; or it may simply be fused in a test-tube, when the salt, curd, and water sink to the bottom and the fat forms a clear yellow stratum above them. The latter of these two ways is far preferable, since it is the quickest and most convenient.

On saponifying fats with caustic potash, these bodies take up three equivalents of water, and form glycerine and the potash salts of palmitic, stearic, and oleic acids; besides these, in the case of butter, butyrate, caproate, caprylate, and caprate of potash. Thus stearin $\left.\begin{array}{c}3C_{18}H_{35}O\\ C_3H_5\end{array}\right\} O_3 + 3\ KHO$ gives $3C_{18}H_{35}KO_2 + C_3H_8O_3$. According to this formula, 100 parts of stearin want 19 parts of potash for complete saponification. In practice it is advisable to take a large excess of caustic potash, at least double as much as butter. The process is in this case much quicker and more complete. On adding sulphuric or hydrochloric acid to the soap, the fatty acids are liberated and sulphate of potash is formed. The products of the process of saponification are, therefore, in all cases glycerine and a mixture of the different fatty acids. Some of them, as oleic, palmitic, and stearic acids, are, as we have shown, insoluble; others, as butyric, caproic, &c., are soluble in water: the soluble acids possess, moreover, the property to be volatile and to distil without decomposition.

The most simple way which seemed to allow of an easy estimation of these volatile acids, appeared to be to decompose the soap with dilute sulphuric acid, to distil the mixture, and thus to obtain these bodies in the distillate. This process is not new, it had been applied many years ago by Chevereul to prepare butyric acid from butter; but a quantitative estimation seems never to have been made.

The following experiments, which we quote from our note-book, were undertaken with this view:—

Experiment I.—Some genuine "farm butter" was fused in warm water to remove the salt, lard, &c. The washed butter-fat was dried; it was perfectly clear when fused, and contained no trace of mineral matter. A weighed quantity of this fat was saponified with caustic potash in a glass flask. The saponification presented many difficulties; the alkaline liquid covered with a stratum of oil, boils most irregularly and violently so as either to break the flask or to cause the liquid to run over. After many unsuccessful experiments, we at last obtained a perfectly clear yellowish soap, which gelatinized in cooling. Dilute sulphuric acid was added, so as to render the liquid strongly acid, which was then distilled. Here, again, we had to contend with the same difficulty as experienced during saponification. The volatile acids in the distillate were estimated by means of standard soda solution and calculated as butyric acid, $C_4H_8O_2$. Found 6·52 per cent.

This number cannot be considered as accurate, since the violent boiling rendered it impossible to make a complete distillation; the distillate was still acid when the experiment was stopped. Although incomplete, this first experiment proved beyond doubt that the quantity of volatile acids in butter is much more considerable than was hitherto supposed, a fact surmised by us from the commencement of our investigations.

Experiment II. — Some genuine butter (sinking point, 35·6) was repeatedly washed with hot water, and treated for purification as above. Taken 9·680 gram. of the dried fat, and saponified in a flask with caustic potash, till a clear transparent soap was obtained, which was the case in about four hours. The soap was decomposed with dilute acid, the liquid heated till the fatty acids floating on the top were just fused to a clear oily liquid, and then cooled again. The fatty acids were then removed by filtration and washed with hot water. The filtrate was distilled and the acidity of the distillate estimated as above. The distillation was extremely slow, but very quiet and easy; the removal of the fatty acids as done in this case is necessary in order to insure this result. The distillate, however, never ceases to be slightly acid, and becomes strongly so when so great a concentration has been reached that the glycerine in the liquid begins to decompose. To fill up with water is of no use, since no trace of acid distils over until the original concentration is re-obtained. Neutralized 6·76 cc. of standard soda solution; 1,000 cc. of this solution neutralize one equivalent = 88 gram. butyric acid, $C_4H_8O_2$; 6·76 cc. = therefore 0·59488 gram., or 6·146 per cent. of butyric acid, a figure which approaches closely that obtained in Experiment I.

Experiment III.—7.494 gram. of the same butter were saponified and treated as just described. Obtained, 7·480 butyric acid, a result not agreeing well with the last.

Experiment IV. — 10 gram. of genuine butter gave a quantity of volatile acids neutralizing 5·79 cc. standard soda solution, 5·094 per cent. of butyric acid.

Experiment V.—10 gram. of same butter as IV. yielded 4·796 per cent.

Experiment VI. — 6·565 gram. of same butter neutralized 5·5 cc. soda solution, 7·4517 per cent. butyric acid.

Experiment VII.—7·346 gram. of the same butter yielded 0·5333 gram. of butyric acid, or 7·259 per cent. Experiments IV. to VII. having been made upon the same butter, prove that by distillation no constant result can be obtained.

Experiment VIII.—Another genuine butter yielded 6·026 per cent. butyric acid. This distillation was carried on so far that the glycerine contained in the solution began to char and to be converted into acrolein; but, notwithstanding, the distillate was still strongly acid, more so indeed than it was at the beginning of the experiment.

It became evident from all these estimations that there are at least from 6 to 7 per cent. of volatile acids in butter-fat, but that it is impossible to obtain the whole amount present by distillation. It was proved sufficiently that the estimation of volatile acids might well be used to distinguish butter from other fats, provided that the amount of them would be found to be constant. The constancy of the sinking point was an indication that also the chemical composition of butter should be constant. Seeing that the direct estimation would not bring us to the desired result, an indirect estimation of the volatile acids was had recourse to. These volatile acids are, as we mentioned, soluble in water, whilst palmitic, stearic, and oleic are insoluble. All animal fats, except butter, are mixtures of the glycerides of the three latter acids. Their equivalents being very high and nearly equal, the theory predicted that they would yield, on saponification and decomposition of the soap with dilute acid, nearly equal amounts of insoluble acids. Thus, pure palmitin would yield 95·28 per cent. of palmitic acid; pure stearin, 95·73 per cent. of stearic acid; and lastly, olein, 95·70 per cent. of oleic acid. All animal fats, being mixtures of these three glycerides, should, therefore, yield a percentage of fatty acids ranging from 95·28 per cent. to 95·73 per cent., or say, on an average, about 95·5 per cent. To prove this theory by experiment, 3 gram. of mutton-fat were saponified in a porcelain basin, with a concentrated solution of potash. The saponification was very easy and quick, the liquid boiling very quietly. Stirring with a glass rod assists very greatly. The evaporating water should be replaced by distilled water, so as to keep the liquid at about from 150 to 200 cc. A perfectly clear soap was obtained, which was decomposed with dilute hydrochloric acid. The fatty acids were fused in the liquid, and filtered through a weighed filter. Before pouring the fatty acids on to the filter, the paper must be well moistened, or some of the fatty acids may pass through it. They were washed with boiling water, dried at 100° C., and weighed. Obtained, 95·63 per cent., which figure agrees with the theory.

Butter, which contains besides palmitic, stearic, and oleic, also volatile or soluble acids, should consequently give a lower amount of insoluble acids, these being diminished in ratio to the quantity of the soluble acids.

Also this reasoning proved to be in strict accordance with the facts. A weighed quantity of butter-fat was saponified, exactly as was the mutton-fat just mentioned; also this saponification, in common with all others, conducted in porcelain basins, was easy to perform, and comparatively quick, it taking about two hours. The soap was decomposed, and the fatty acids were fused on the liquid, to ensure complete decomposition of the soap. If the fusion be not completed till they form a perfectly clear oil, they invariably contain some mineral matter, making the experiment valueless. The fatty acids were washed upon the filter with about half a litre of boiling water, till the reaction of the filtrate was no longer acid. It is necessary to use so large an amount of wash-water, since we found that the acids dry much quicker, and their weight gets sooner constant, than if only a small quantity of water be used. This arises from the fact that the caprylic acid is very sparingly soluble in water, and volatilizes on drying. The filter is now taken cautiously out of the funnel, and dried in a weighed basin.

Obtained, 86·07 *per cent. of insoluble acids, or* 9·5 *per cent. less than any other fat could have given.*

In decomposing the soap with dilute acid, a very violent action ensues if the liquid be hot, and a strong smell of butyric acid is observable. A perfect soap is quite clear and transparent, of a yellowish colour, and congeals into a jelly on cooling, if it be not too concentrated. In this case the soap separates, and forms a layer on the top of the alkaline ley. Most other fats give a nearly colourless soap; but this fact cannot be used as a test of the purity of butter. It might reasonably be supposed that the fatty acids would cling to the vessel, and be difficult to wash upon the filter; this is not the case if water quite boiling be used, in which case the filtration is very rapid.

It now remains for us to prove that all other fats, like mutton-fat, yield 95·5 per cent. of fixed fatty acids, and all butter fats 86 per cent.; we therefore give the following experiments:—

Experiment I.—Took three gram. of lard, and treated in the manner just described. Saponification was extremely slow. Obtained, 95·70 of fixed acids.

Experiment II.—Three gram. of mixed dripping, sinking point, 42·6, were saponified.

Also in this case the saponification was very slow. Obtained, 2·855 gram., or 95·17 of fixed acids.

Experiment III.—Three gram. of cocoa butter, obtained from Messrs. Cadbury Brothers, were saponified. This is a highly interesting fat. It has nearly the same sinking point as butter, namely, 34·9° C., but is at ordinary temperatures quite hard and solid ; it, however, fuses easily, and melts on the tongue with a peculiar smoothness; it is fragrant and sweet-flavoured; it never turns rancid, and promises to become a very useful article in the market. It cannot be used as an adulterant for butter. Obtained, 2·850 gram., or 95·0 per cent. of fatty acids.

Experiment IV.—3·267 gram. of palm-oil were saponified. It saponified easily, and formed a clear reddish soap of peculiar smell. When decomposed, the fatty acids separate as a reddish mass, which becomes nearly colourless on drying in the water-bath ; also the filtrate was perfectly colourless. Obtained, 93·94 per cent. of fatty acids. The difference of 1·5 per cent. may be accounted for by the large quantity of colouring matter present.

Palm-oil has often been stated to be used as an adulterant of butter. We think that its very deep orange-colour, disagreeable smell and taste, and its profusely crystalline structure, render it perfectly unfit for such a purpose.

Other experiments, leading to similar results, were made, but it would be useless repetition to quote them. It is hardly necessary to remark that on decomposing the soap with dilute acid, no smell was observed. This is a distinctive difference between butter and other fats.

With regard to butter-fats, the following experiments are quoted to prove their constant composition:—

Experiment I.—Three gram. of genuine farm butter-fat yielded 2·567 gram., or 85·56 per cent. of fixed fatty acids.

Experiment II.—3·159 gram. of butter-fat yielded 2·922 gram., or 86·16 per cent. of fixed acids.

Experiment III.—3·170 gram. of another sample gave 2·717 gram., or 85·71 per cent.

Experiment IV.—3·257 gram. of fat from salt butter gave 2·796 gram., or 85·84 per cent.

Experiment V.—4·043 gram. of fat from fresh Sussex butter yielded 86·20 per cent. of fatty acids.

Experiment VI.—3·302 gram. of fat from best Normandy butter yielded 3·076 gram., or 85·40 per cent.

Experiment VII.—3·027 gram. of Jersey butter-fat gave 2·606 gram. of fatty acids, equal to 86·09 per cent.

Experiment VIII.—2·812 gram. of fat from another Jersey butter yielded 89·13 per cent. of insoluble fatty acids.

Experiment IX.—3·108 gram. of butter-fat from Guildford gave 86·06 per cent. of fixed acids.

Experiment X.—3·244 gram. of butter-fat yielded 2·772 gram., or 85·48 per cent.

Experiment XI.—To see how far the quantity of fatty acids may be influenced by rancidity, 3·00 gram. of a strongly rancid butter-fat were saponified. Obtained, 2·567 gram., or 85·57 per cent. of insoluble fatty acids; thus proving that rancidity does not materially interfere with the accuracy of our method.

The quantity of fatty acids obtained from the twelve different samples of butter quoted in this chapter, varies from 85·40 to 86·20 per cent., showing a difference of 0·8 per cent. It is remarkable to notice, that the composition of butter-fat is exactly as constant as the amount of "solids not fat" in milk, upon which Mr. Wanklyn has based his method for the analysis of that article.

The average of the above twelve results is 85·85 per cent. of fixed acids. *The difference between the quantity of fatty acids found in butter and that found in other fats is therefore on an average 9·65 per cent.* Mixtures will yield quantities lying between 85·85 and 95·5 per cent. An adulteration of 100 per cent., *i.e.* the substitution of any foreign fat for butter, would give a difference of 9·65 per cent.; an adulteration of 10 per cent., therefore, would give a difference of 0·965 per cent. Each tenth of a per-centage of fatty acids above the average figure would consequently be equal to 1·036 per cent. of adulteration; but, as in the case of milk, however, it would be unjustifiable to declare a sample of butter to be adulterated because the fatty acids lie three or four tenths of a per-centage above the average figure. A difference of one-half per cent. and above would, of course, constitute an adulteration.

To give an idea of the accuracy which may be obtained by our method, the one of us prepared mixtures of foreign fat with butter which the other analysed, without having an idea of their composition.

Mixture I.—27·70 gram. of genuine butter were fused together with 5·82 gram. of lard. The mixture contained, therefore, 82·7 per cent. of butter and 17·3 per cent. of lard. On analysis, however, the butter is freed from water, salt, and curd; the mixture of the fats, therefore, is really somewhat different in composition, as we will show.

100 parts of butter being equal to 85 parts of butter-fat, 82·7 of butter equal 70·29 per cent. of fat; the above mixture, therefore, consists of 70·29 parts of butter-fat, and 17·3 parts of lard, or, calculated for 100, of 80·2 of butter-fat and 19·8 of lard.

3·221 gram. of this mixture were saponified. The saponification was slow, but the soap presented exactly the same appearance as that obtained from genuine butter. Obtained 87·48 per cent. of fatty acids, or 1·63 per cent. more than genuine butter would yield. 1 per cent. of difference being equal to 10·36 per cent. of admixture; the fat analysed contained, therefore, 16·88 per cent. of fat not butter-fat. This calculated back to the original mixture, containing water, curd, and salt, gives 14·7 per cent. of foreign fat and 85·3 per cent. of butter. Taken 17·3 per cent., found 14·7 per cent. of foreign fat; difference, 2·6 per cent., a satisfactory result.

Mixture II.—81·1 per cent. of butter and 18·88 per cent. of foreign fat were mixed together. Calculated as fats only, the mixture contains 78·5 per cent. of butter-fat and 21·5 per cent. of foreign fat. Saponified 2·874 gram., yielding 87·89 per cent. of fatty acids. The difference between 87·89 and the average of pure butter-fat, 85·85, is 2·04 per cent. The fat contained, therefore, 21·13 per cent. of fat not butter. Taking into calculation water, curd, and salt, the original mixture consists therefore of 18·55 per cent. of foreign fat and 81·45 per cent. of butter. Taken 18·88 per cent. of foreign fat, found 18·55 per cent.; difference, 0·33 per cent.

Mixture III.—A third mixture, consisting of 69·79 of butter and 31·21 per cent. of beef-fat, was analysed. Obtained, 89·23 per cent. of fatty acids, or 3·38 per cent. more than pure butter-fat could yield. This number, multiplied by 10·36 gives, as shown, the amount of admixture in per-centages, in this case 35·02. Calculated back as above, the orginal mixture was found to consist of 31·42 per cent. of foreign fat and 86·58 per cent. of butter, there being a difference of 1·2 per cent. between the amount found and that really taken.

The sinking point of this mixture 39·5° C., or 4·0 degrees higher than that of genuine butter. These 4·0 degrees are due to 35·02 per cent. of foreign fat; 100 per cent. of it would, therefore, raise the sinking point 11·4 degrees, making it 46·9° C.; fat having a high fusing point (in this case ox-fat) has, therefore, been used as an adulterant.

These results show that our method is satisfactory, and, at least, as accurate as any other method employed in food analysis. We claim for it, also, that it is entirely new and original, and that an accurate analysis of butter can be done by it, including all the processes we have described, in two days.

We give, further, the analysis of two samples of articles sold as butter.

The first example, a salt butter, looked suspicious; it was full of crystals, showing that some part of it had been fused, was loose in texture and opaque in appearance. 3 gram. were saponified, and yielded 92·67 per cent. of fatty acids, or 6·82 per cent. more than genuine butter. The fatty portion of the sample contains, therefore, 70·65 per cent. of foreign fat, and only 29·35 per cent. of butter-fat. Original article was, therefore, prepared by mixing 32·83 parts of genuine butter with 67·17 of foreign fat. The sinking point of the article was normal, namely,—35·9° C.; the fat used as adulterant had, therefore, a sinking point very near that of genuine butter, and was probably dripping.

The second adulterated butter was so-called "Kiel-butter," price 1s. per lb. Of dark colour, opaque, reddish, and full of polarizing crystals. Being fused in a test-tube, a deep hollow cone was formed on cooling. Sinking point 38·4° or 2·9° higher than that of genuine butter. All these facts indicate that this butter is not genuine. This suspicion was confirmed by chemical analysis. It yielded 89·79 per cent. of fixed acids, or 3·94 per cent. more than genuine butter. The fatty portion of it contains, therefore, 40·6 per cent. foreign fat. Calculated for the original butter, the article consists of 36·7 per cent. foreign fat and 63·3 per cent. of genuine butter. The sinking point of the adulterant must have been 43·3° C.

THE END.

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